COMPARISON OF RED-COCKADED WOODPECKER (PICOIDES BOREALIS) NESTLING DIET IN OLD-GROWTH AND OLD-FIELD LONGLEAF PINE (PINUS PALUSTRIS) HABITATS

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Comparison of Red-cockaded Woodpecker (Picoides borealis) Nestling Diet in Old-growth and Old-field Longleaf Pine (Pinus palustris) Habitats

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ABSTRACT.—Automatic cameras were used to record adult red-cockaded woodpecker (*Picoides borealis*) nest visits with food for nestlings. Diet of nestlings on or near an old-growth longleaf pine (*Pinus palustris*) remnant in southern Georgia was compared to that in longleaf pine stands established on old farm fields in western South Carolina. Diets of nestlings were expressed as percent nest visits and percent prey biomass. The method of calculating nestling diet composition had little effect on the relative ranking of prey. Roaches (Blattaria: Blatellidae) were the most common arthropod fed to nestlings, ranging from 33–57% of the prey brought to nest cavities by adults or 55–73% of the prey biomass. Other common prey were spiders, centipedes and caterpillars. The latter were primarily larvae of coneworms (Lepidoptera: Pyralidae, *Dioryctria* spp.) that bore into and feed on pine cones. Scorpions (Scorpiones: Buthidae, *Centruroides* sp.), an unusual prey, were recorded several times at the south Georgia location. Morisita's index (C) of diet overlap showed a high degree of similarity in nestling diets among years in the old-growth remnant (C = 0.91 to 0.94), as well as a high degree of similarity in the diets of nestlings among woodpecker groups within locations and between old-growth and old-field habitats (C = 0.89–0.95). Our study shows that old trees on relatively undisturbed sites provide the same prey as younger trees growing on old farm fields and the relative importance of the different prey was similar for both habitats.

INTRODUCTION

Red-cockaded woodpecker (*Picoides borealis*) populations, listed as endangered in 1970, continue to decline following decades of intensive forest management, fire suppression and increasing urbanization. However, this woodpecker responds positively to improved habitat management (Escano, 1995). As knowledge of this bird's habitat needs increases (Kulhavy *et al.*, 1995), emphasis is being placed on restoring pine ecosystems, but questions remain about how red-cockaded woodpeckers are affected by quality and quantity of their foraging habitat. Red-cockaded woodpeckers live in pine (*Pinus* spp.) forests throughout the southeastern United States. Nest cavities are constructed in live, heart-rot infected pine trees (Conner *et al.*, 1976) and foraging is almost exclusively on the boles and branches of live trees (Hooper and Lennartz, 1981; Zwicker and Walters, 1999). The red-cockaded woodpecker is a cooperative breeder so a territory is occupied by a group of birds consisting of a breeding pair and up to four helper males (Walters *et al.*, 1992). Red-cockaded woodpeckers prefer foraging on trees over 25 cm diameter and on the largest and presumably the oldest trees in mixed-age stands (Engstrom and Sanders, 1997; Zwicker and Walters, 1999). Because of these nesting and foraging habits, the red-cockaded woodpecker is sometimes regarded as an old-growth forest species.

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A number of studies have reported the red-cockaded woodpecker's diet (Beal, 1911; Harlow and Lennartz, 1977; Hanula and Franzreb, 1995; Hess and James, 1998; Hanula *et al.*, 2000a). However, all of these studies were in second-growth or younger forests. The most extensive diet studies were on old fields reforested with pines in the 1940s and 1950s (Hanula and Franzreb, 1995; Hanula *et al.*, 2000a).

Engstrom and Sanders (1997) suggested that high woodpecker population densities, high reproductive rates and small home ranges in and adjacent to an old-growth longleaf pine (*Pinus palustris*) stand indicated high quality habitat for red-cockaded woodpeckers. Because old-growth longleaf pine is sometimes considered to be the optimum habitat for this species (Engstrom and Sanders, 1997), between 1995 and 1997 we studied the diet of red-cockaded woodpecker nestlings in an old-growth remnant stand in southern Georgia. We compared the diet of nestlings in old-growth stands to the diet of nestlings in stands established on old farm fields in western South Carolina.

METHODS

The study was conducted on the Wade Tract near Thomasville, Georgia, and the Savannah River Site near Aiken, South Carolina. The Wade Tract, described in detail by Platt *et al.* (1988), is an 80 ha remnant of old-growth longleaf pine (>250 y old) surrounded by mature longleaf pine (30+ y old). Distributions of red-cockaded woodpecker groups (a group consists of a breeding male and female plus their helper males) and their foraging territories in and around the Wade Tract were described by Engstrom and Sanders (1997). The Wade Tract is located in the Red Hills area of the southern Coastal Plain physiographic province, which is noted for its red soils with thin to moderate loamy surface sands. It has a relatively undisturbed ground cover dominated by wiregrass (*Aristida beyrichiana*), bracken fern (*Pteridium aquilinum*) and runner oak (*Quercus pumila*). The Wade Tract receives a prescribed burn during the growing season every 2 y.

The Savannah River Site, a nuclear production facility in western South Carolina, was primarily agricultural fields reforested with pines. Most red-cockaded woodpecker habitat was in 50- to 60-y-old longleaf pine plantations mixed with some loblolly (*Pinus taeda*) and slash pine (*P. elliotti*). Understory vegetation varied among stands, but none of the stands contained wiregrass. Longleaf pine stands on the Savannah River Site generally receive prescribed burns during the winter on a 4–5 y cycle.

The study was conducted during the woodpecker breeding seasons of 1995–1997 using automatic cameras to record red-cockaded woodpecker adults as they returned to their nest cavities with food for nestlings. The cameras and techniques were described by Hanula and Franzreb (1995), but, because several cavities on the Wade Tract were high above the ground (>13 m), we used 1000-mm Sigma APO lenses instead of 500-mm lenses, when necessary. The longer lenses required larger water tight housings that were too heavy for the 3 m tall tripods used with the smaller lenses, so we mounted them on 1.3 × 1.3 × 1.3 m wooden platforms. In 1997 we elevated the wooden platform an additional 4 m on standard commercial steel scaffolding to record nest visits to a cavity 24 m aboveground. The duration of observations at a given nest varied. Whenever possible we placed cameras at nest cavities 5–7 d after egg hatch and photographed visits until the nestlings left the cavity. Cameras were moved to other cavities within the same site after the first group of nestlings fledged. Nest cavity selection was based on availability so the age of the nestlings varied. Nest visits were recorded for 1–3 wk at each cavity depending on the age of the nestlings at the time the cameras were set up.

In 1995 we recorded nest visits by 1 group of woodpeckers on the Wade Tract and 4 groups on the Savannah River Site. In 1996 we recorded visits by 2 groups on the Wade

Tract and 4 groups on the Savannah River Site. In 1997 we recorded nest visits by 2 groups on the Wade Tract and 5 groups on the Savannah River Site. On the Wade Tract, 1 group was observed twice, once in 1996 and again in 1997.

Photographic slides of nest visits with prey items (1 visit/slide) were examined at 10–20× magnification. Prey items were identified to the lowest taxonomic level possible and the proportion of the total nest visits with each prey type was calculated. We used Morisita's index (C) of diet overlap (Litvaitus *et al.*, 1996), which is considered the least biased diet overlap estimator (Smith and Zaret, 1982), to quantify the similarity of red-cockaded woodpecker prey on the two sites and among years at the south Georgia location. This index produces a number between 0 and 1, where 0 means no similarity or overlap in diets and 1 indicates the diets overlap completely.

Prey biomass was estimated for the most common prey types using biomass estimates of individual prey items from previous studies (Hanula *et al.*, 2000b) or from laboratory reared or field collected specimens. Biomass estimates were based on oven-dried weights (48 h at 50 C) of 15 or more individuals. For some prey groups it was impossible to know which species were used by the woodpeckers, or they used several species, so large species commonly captured on tree boles were chosen to be representative of the group to minimize bias. For example, we used a large *Lycosa* sp. (Araneae: Lycosidae) to estimate spider biomass, laboratory reared fifth instar southern pine coneworms (Lepidoptera: Pyralidae, *Dioryctria amatella*) to estimate caterpillar and pupa biomass, *Melanotus* sp. (Coleoptera: Elateridae) click beetles to estimate beetle and unidentified insect biomass, mid- to late-instar Cerambycidae to estimate wood borer larval biomass, adult *Parcoblatta* sp. (Blattaria: Blatellidae) to estimate wood roach biomass and adult *Camponotus nearticus* (Hymenoptera: Formicidae) to represent ants. Visits recorded as "insect larvae" were probably ants so the two categories were combined for biomass calculations. Woodpeckers always returned with several ants per visit so, based on counts of larvae visible in the photographs, we used an estimate of five ants per visit to calculate ant biomass. Prey biomass was expressed as a percentage of the total biomass for comparisons within and between locations.

RESULTS

Twenty-five prey types were identified from the photographs (Table 1). Wood roaches comprised 33–57% of nestling diets and were the most common prey used to feed nestlings regardless of location or year. A broad "insect" category made up 3–17% of the diet. We used this category when we were able to see wings, legs or body shapes that were clearly insects but could not identify them further for a variety of reasons (*e.g.*, low light, dew or glare on the glass, cameras out of focus). Woodpeckers consistently used caterpillars at both locations. Caterpillars were primarily coneworms (*Dioryctria* spp.) that bore into and feed on pine cones, although one species also feeds in wounds or disease cankers on tree boles. Other common dietary items were spiders (Araneae), wood borer larvae (Coleoptera: Cerambycidae), centipedes (Scolopendromorpha) and beetle adults (Coleoptera). These arthropods, combined with roaches and caterpillars, made up over 60% of the nestlings' diet. Biomass estimates of nestling diets showed a similar trend (Table 2). Roaches made up 55–73% of the total biomass while other prey items varied in importance depending on location or year of observation.

Using Morisita's index we found a high degree of similarity in diet at the Savannah River Site and the south Georgia location in 1996 and 1997 (C = 0.89 and 0.95, respectively), as well as in nestling diet among years (C = 0.91 in 1996 and 0.94 in 1997) on the Wade Tract.

TABLE 1.—Diet of nestling red-cockaded woodpeckers, expressed as percent of nest visits by adults with a prey type, in an old-growth longleaf pine remnant (Wade Tract = WT) and a longleaf habitat established on old farm fields (Savannah River Site = SR) during the nesting seasons of 1995–1997; numbers in () denote number of woodpecker groups observed. Each prey type was identified to the lowest taxonomic level possible. Prey were categorized as singular when one was brought back per visit or plural when more than one were brought back in each visit

	% nest visits					
	1995		1996		1997	
Prey type	SR (4)[1] n = 2281	WT (1) n = 310	SR (4) n = 1790	WT (2) n = 158	SR (5) n = 1630	WT (2) n = 359
Wood roach (Blattaria: Blatellidae)	56.8	48.8	52.3	32.9	55	51.3
Caterpillar (Lepidoptera)	8.4	4.8	17.1	4.4	3.4	14.5
Spider (Araneae)	7.3	12.3	6.4	3.7	8	7
Wood borer larva (Coleoptera: Cerambycidae)	5.5	0.3	0.7	13.3	17.1	0.6
Centipede (Scolopendromorpha)	4.6	4.5	4.3	8.2	3.5	7.8
Beetle adult (Coleoptera)	3.8	1	1.7	3.2	1.1	3.1
Insect larvae/pupae	3.2	3.5	1.9	2.5	1.1	1.7
Insect larva/pupa	3	3.2	3.3	20.9	3.5	5
Insect (unidentifiable)	2.1	16.5	7.4	3.2	4.5	4.2
Lepidoptera pupa	2.3	0.1	1.6	3.1	0.2	2.2
Ant larvae and/or adults (Hymenoptera: Formicidae)	2.2	0.3	1.3	3.2	1.7	0.8
Hymenoptera larva	0.4	1.9	0.4	0.6	<0.1	0
Beetle larva/pupa	0.6	0.3	0.1	0	<0.1	0.3
Moth (Lepidoptera)	0.4	0	0.7	0	0.3	0
Cricket (Orthoptera: Gryllidae)	0.3	0	<0.1	0	0	0
Cicada (Homoptera: Cicadidae)	0.2	0	0.3	0	0.3	0.3
Hemiptera adult	0.1	0	0	0	<0.1	0
Snail shell	0.1	0	0.2	0	0	0
Fly adult (Diptera)	<0.1	0	0	0	0	0
Long-horned grasshopper (Orthoptera: Tettigoniidae)	<0.1	0	<0.1	0	0	0
Short-horned grasshopper (Orthoptera: Acrididae)	<0.1	0	0	0	0	0
Shieldback bug (Hemiptera: Scuttelleridae)	<0.1	0	0	0	0	0
Wasp (Hymenoptera)	<0.1	0.3	0.1	0	0	0
Scorpion (Scorpiones: Buthidae, *Centruroides* sp.)	0	0.3	0	0	0	1.4
Homoptera adults	0	0	0.1	0	0	0

[1] Data from the Savannah River Site in 1995 are from Hanula *et al.* (2000a) and are presented here for comparison

TABLE 2.—Diet of nestling red-cockaded woodpeckers, expressed as percent of total biomass[1] (g ovendry weight) of the 9 most common prey items, in an old-growth longleaf pine remnant (Wade Tract = WT) and a longleaf habitat established on old farm fields (Savannah River Site = SR) during the nesting seasons of 1995–1997

	1995				1996				1997			
	SR		WT		SR		WT		SR		WT	
Prey type	g	%	g	%	g	%	g	%	g	%	g	%
Wood roach	122.3	73.1	14.3	65.3	89.9	69.2	4.9	55.7	84.6	70	17.4	68.5
Caterpillar	12.8	7.7	0.8	3.7	17.5	13.5	0.6	6.8	3	2.5	3.1	12.2
Spider	10.9	6.5	2.5	11.4	7.5	5.8	0.4	4.5	8.5	7	1.6	6.3
Centipede	5.9	3.5	0.8	3.7	4.3	3.3	0.7	8	3.2	2.6	1.6	6.3
Wood borer larva	6.9	4.1	<0.1	0.3	0.7	0.5	1.2	13.6	15.6	12.9	0.1	0.4
Beetle adult	2	1.2	<0.1	0.3	0.7	0.5	0.1	1.1	0.4	0.3	0.3	1.2
Ants	2.6	1.6	0.2	1	0.7	0.5	0.1	1.1	0.4	0.3	0.1	0.4
Insect larva	1.1	0.7	0.2	1	0.9	0.7	0.5	5.7	0.9	0.7	0.3	1.2
Insect	2.8	1.7	2.9	13.3	7.7	5.9	0.3	3.4	4.2	3.5	0.9	3.5

[1] Biomass estimates are based on oven-dried weights (48 h at 50 C) of 15 or more individuals

DISCUSSION

The Wade tract and nearby forested areas contain large, old and widely spaced overstory longleaf pine with a diverse wiregrass-dominated understory that may well be similar to what this forest type looked like before European settlers arrived in the Red Hills area (Platt *et al.*, 1988). In contrast, the Savannah River Site has much younger overstory trees and a comparatively sparse, low-diversity understory. Despite these differences, red-cockaded woodpecker nestling diets were very similar. Thus, the age of the overstory and the degree of past disturbance had little effect on the type of prey these birds used to feed its nestlings.

Our results are consistent with other studies that showed wood roaches constituted a high proportion of red-cockaded woodpecker nestling diets regardless of year observed or geographic location (Hanula and Franzreb, 1995; Hanula *et al.*, 2000a). Other prey were also similar to those observed in earlier studies. Scorpions were the only prey recorded on the Wade Tract not observed at the Savannah River Site. Hess and James (1998) listed scorpions as prey but did not indicate how many or whether they were eaten by nestlings or adults. The relative ranking of prey changed very little when prey abundance was expressed as percent biomass (Table 2). Percent biomass results show that previous diet analyses based on percent nest visits (Hanula and Franzreb, 1995; Hanula *et al.*, 2000a) were conservative and accurate assessments of the relative importance of the different prey.

In contrast to our results, Hess and James (1998) found few wood roaches in the stomach contents of nestlings on the Wakulla Ranger District of the Apalachicola National Forest in Florida < 100 km from the Wade Tract. They suggested that the differences in nestling diet in Florida and the Savannah River Site (Hanula and Franzreb, 1995) were due in part to the old-field habitat of the latter, and local and regional variations in foraging habitat. However, this and other studies (Hanula and Franzreb, 1995; Hanula *et al.*, 2000a) demonstrate that despite widely differing forest conditions the diet of red-cockaded woodpecker nestlings is similar across a broad geographical area. Although, the availability of prey species is likely to vary among locations because arthropod populations are often cyclical, old-field habitats do not appear to differ in the types of prey available for the woodpeckers.

Zwicker and Walters (1999) observed that red-cockaded woodpeckers prefer to forage on older trees and hypothesized that old trees may harbor a different community of arthropods than younger trees. However, diet studies show that the woodpeckers choose similar common prey throughout their range, although the relative abundance of the prey may vary depending on location, method of diet analysis or stage of woodpecker development (Beal, 1911; Harlow and Lennartz, 1977; Hanula and Franzreb, 1995; Hess and James, 1998; Hanula *et al.*, 2000a). In addition, 60- to 80-y-old longleaf pine trees have the same arthropod biomass on them as older trees (Hooper, 1996; Hanula *et al.*, 2000b). It is unclear why red-cockaded woodpeckers prefer foraging on older trees but our study shows that they selected the same prey from old and young trees and the relative importance of various prey fed to nestlings was similar regardless of the age of the dominant trees in the foraging habitat.

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